Health Consultation

Analysis of Risk Factors for Childhood Blood Lead Levels El Paso, Texas, 1997–2002

El Paso, El Paso County, Texas

EPA Facility ID: TX0000605388

April 20, 2004

Prepared by the
Texas Department of Health
Under a Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry
U.S. Department of Health and Human Services

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Summary and Statement of Issues

This report provides the results of our analysis of risk factors for elevated blood lead levels in children living in El Paso, Texas. Over the past several years, the U.S. Environmental Protection Agency (EPA) Region 6, in cooperation with the Texas Department of Health (TDH), the Agency for Toxic Substances and Disease Registry (ATSDR), the Texas Commission on Environmental Quality (TCEQ), and local city and county officials have been investigating soil contamination in residential yards in El Paso, Texas. People in the area have expressed concern that the levels of lead in the soil in the area may be associated with elevated blood lead levels in children. In response to these concerns, EPA, TCEQ, the City of El Paso, and various citizens' groups asked TDH and ATSDR to evaluate whether the soil lead level in El Paso is a risk factor for elevated blood lead levels in children.

TDH performed two separate analyses to evaluate the significance of soil lead levels to childhood blood lead levels. The analyses used existing data sets to accomplish these primary objectives:

- Identify predictors or risk factors for elevated blood lead levels in children in El Paso.
- Evaluate, while controlling for other risk factors, whether soil lead levels significantly predict whether children (0–6 years of age) have elevated blood lead levels.

We used Geographical Information System (GIS) mapping to bring together several sources of information. We obtained this information in the form of data sets from the Texas Childhood Lead Poisoning Prevention Program (CLPPP), the U.S. Census, the El Paso County appraiser's office, and from ATSDR.

We used multiple logistic regression modeling on these data sets to conduct two separate analyses. The first analysis was for the greater El Paso area. In this analysis, we used data for all of El Paso to identify predictors or risk factors for elevated blood lead levels. In the second analysis, we matched the soil lead and blood lead data sets to assess whether soil lead levels significantly predict whether children (0–6 years of age) have elevated blood lead levels while controlling for the other risk factors.

We found a significant association between soil lead and blood lead test results. A 500 parts per million (ppm) change in soil lead was associated with a 4.5 times increase in the odds of a child having an elevated blood lead level. Although we found a significant association regardless of whether we modeled the blood lead as a binary or a continuous variable, there was a difference in the extent of soil lead's ability to predict blood lead levels in these models. This finding is not surprising, considering the potential for a combination of multiple low-level exposures to lead from many sources and pathways.

On the basis of the results of our analysis, recognition of the multisource nature of lead exposure, and review of the large body of literature on the importance of the soil/dust pathway, we have concluded that soil lead probably contributes to elevated blood lead levels in this population of children in El Paso.

Background

Over the course of the past several years, the U.S. Environmental Protection Agency (EPA) Region 6, in cooperation with the Texas Department of Health (TDH), the Agency for Toxic Substances and Disease Registry (ATSDR), the Texas Commission on Environmental Quality (TCEQ), and local city and county officials have been investigating soil contamination in residential yards in El Paso, Texas. Much of the history pertaining to the study of this contamination has focused on a smelter that occupies 123 acres of a 585-acre property along the Rio Grande, near the border between the United States and Mexico. In November 2002, EPA began a time-critical removal action to remove soil from yards in residential neighborhoods with the highest levels of lead contamination. The site is now being evaluated for listing on EPA's National Priorities List for Uncontrolled Hazardous Waste Sites (NPL). However, people in the area have expressed concerns that soil lead levels might affect childhood blood lead levels. In response to these concerns, EPA, TCEQ, the City of El Paso, and various citizens' groups asked TDH and ATSDR to use available information to evaluate whether soil lead in El Paso is a risk factor for elevated blood lead levels in children.

Rationale for the Analysis

Because lead is ubiquitous in the environment, children may be exposed to lead from many different sources and through many different pathways. Multiple low-level exposures can result in a significant combined exposure. For many children with blood lead levels that are low but still elevated, identifying a single predominant source or pathway is not always possible. Some of the most common sources for lead exposure include lead-based paint, soil and dust, drinking water, occupations and hobbies of parents or care givers, air, and food. For some children, "traditional" medicines are a source of lead exposure. Other factors that have been associated with elevated blood lead levels include a child's age, socioeconomic status, and distance to a point source of lead (*1-16*). Because lead is believed to pose the greatest danger to young children, we focused our analyses on children ages 0 to 6 years old.

To assess whether soil lead is a predictor of elevated blood lead levels in children, we conducted two separate analyses. The first analysis was for the Greater El Paso area. For the Greater El Paso analysis, we used multiple logistic regression analysis to identify the predictors or risk factors for elevated blood lead levels in the 1997–2002 Texas Childhood Lead Poisoning Prevention Program (CLPPP) data for the greater El Paso area. The second analysis matched soil lead and blood lead data sets. In the Soil-Matched analysis, while controlling for the risk factors identified in the first analysis, we used multiple logistic regression modeling on a much smaller data set containing matched soil lead/blood lead data to assess whether soil lead levels significantly predict elevated blood lead levels in children (0–6 years of age). We also used ordinary least squares regression analysis to model blood lead level as a continuous variable to evaluate whether soil lead levels contributed statistically to blood lead levels in this data set and, if so, to what extent.

Methodology

Overview

We used Geographical Information System (GIS) mapping to bring together several sources of information to assess whether a statistical relationship exists between various risk factors and childhood lead poisoning in El Paso, Texas. We obtained this information in the form of data sets from the Texas Childhood Lead Poisoning Prevention Program (CLPPP), the U.S. Census, the El Paso County appraiser's office, and the EPA through ATSDR. Statistical Analysis System software was used for all the statistical calculations performed in our analyses.

Data Used

The Texas Childhood Lead Poisoning Prevention Program has maintained surveillance data for all blood lead test results reported on children throughout the state of Texas since 1996. From CLPPP, we obtained data for all blood lead results for children tested between 1997 and 2002 who had El Paso listed as their city of residence. We limited the data set to children between 0 and 6 years of age and identified those children who had an elevated blood lead level using the CDC's definition of a confirmed elevated blood lead level. If either 1) a child's first test was from a venous sample and was elevated or 2) if a child screened elevated with a capillary test and was then retested within 12 weeks was again elevated then the child was considered to have a confirmed elevated blood lead level. To have a single record for each child, we removed duplicate and subsequent repeated samples of the same child. This data set consisted of 39,145 children. From the CLPPP data set, we were also able to obtain information on the child's sex and the child's age at testing.

The Geographic Information Systems group at the TDH Center for Health Statistics geocoded the childhood blood lead data set to create a GIS file for further analysis and geographic matching with other data sources. The TDH GIS group successfully identified the geographic coordinates (geocoded) of the residences of 38,725 (98.9% of the original 39,145) of these children. Of the 38,725 children whose residences were geocoded, we identified a subset of 38,258 children who either screened negative or had a confirmed elevated blood lead level (this excludes unconfirmed positive tests). The TDH-GIS group matched the CLPPP data with data from the 2000 U.S. Census, enabling them to obtain information on the neighborhoods in which the children lived. They were able to identify the percentage of people living below the national poverty level for the block group each child lived in at the time of testing. They were also able to identify for each child's census tract the percentage of the population that had emigrated from Mexico between 1990 and 2000. The GIS group also calculated the distance from each child's residence at time of testing to the smelter (latitude of 31.775364N and longitude of 106.521684W). The GIS group then added additional data fields to the CLPPP data for poverty, Mexican immigration, and distance to the smelter.

We used age of housing, obtained from the El Paso County Appraisal District, as a surrogate for whether a child's residence might contain lead-based paint. The Centers for Disease Control and Prevention (CDC) estimates that approximately 74% of privately owned homes in the United States built before 1980 contain lead-based paint. Prior to the 1940s, lead-based paint (containing up to 50% lead) was in widespread use. The concentration of lead in paint decreased after the 1940s, and the use of interior lead-based paint decreased during the 1950s and 1960s (exterior lead-based paint was widely available until the mid-1970s). In 1978, the Consumer Product Safety Commission banned paint for residential use that contained more than 0.06% lead by weight. The TDH-GIS group geocoded El Paso County appraisal district data for the year 2000, matched that data to CLPPP data, and added a data field to the CLPPP data for the age of the child's residence at the time of blood lead testing. Of the 156,690 records in the El Paso County appraisal district's data on housing age for the year 2000, the TDH-GIS group was able to directly match 25,772 of the CLPPP records (67.3% of the 38,725) to the data on individual housing age.

Through a cooperative agreement with ATSDR, in October of 2003 we obtained data on residential soil lead levels recently collected by EPA. This data set contained surface-soil sampling results from 2,036 separate residences. The TDH-GIS group matched that soil data to the 1997 to 2002 CLPPP data and added a field in the data set for the average soil lead level for each residence. We were able to directly match 497 children from the CLPPP data set to the residential soil data; 484 had either screened negative or had a confirmed elevated blood lead test. We also identified 3,436 children in the CLPPP data set with residences within 1,000 feet of residential soil lead tests performed by the EPA.

We calculated the percentage of children with elevated blood lead levels (>10 micrograms per deciliter [μg/dL]) for each data set (original CLPPP, CLPPP geocoded, soil sampling area, and soil direct match) for both the combined results (nonelevated, nonconfirmed elevated, and confirmed elevated) and confirmed results (nonelevated and confirmed elevated). The percentage of children with elevated blood lead levels ranged from 2.2% to 5.2% for the combined results and from 1.2% to 2.7% for the confirmed results (Table 1).

Analyses Performed

Analytical Data Sets

We made use of two analytical data sets from the CLPPP data that had been augmented by the census and appraisal district data sets. For the Greater El Paso analysis, the analytical data set consisted of all children from the CLPPP data who met three criteria: the record contained valid address information; the address was successfully geocoded by Geographic Information Systems software; and the child had either screened negative for elevated blood lead levels or screened positive and had a second test to confirm the results. The analytical data set for all of El Paso consisted of 38,258 children for the years 1997 through 2002. For the Soil-Matched analysis, we used a smaller analytical data set: children who lived in a house for which we had soil lead results and for whom we had blood lead data. The number of children in that data set totaled 484.

Greater El Paso Analysis

For the 38,258 children in the greater El Paso area in the augmented CLPPP data set, we calculated simple descriptive statistics for both the categorical and continuous variables in the data (Tables 2 and 3). We created crosstabulation tables for potential socioeconomic risk factors versus the percentage of elevated blood lead levels found in children within groupings (Table 4) and then created the associated graphs (Appendix B, Figures 1 through 7). The potential risk factors for elevated blood lead levels in children assessed in this analysis included the following.

Potential risk factor	Original data source
Child's age (and age-squared)	CLPPP
Housing age	El Paso County appraisal district
Percentage poverty in block group	2000 U.S. Census
Percentage of population in census tract who immigrated from Mexico 1990–2000	2000 U.S. Census
Distance to smelter	Calculated using GIS

In preparation for the regression analysis, we created correlation and scatterplot matrices for the potential predictor variables for data visualization and assessment of predictor correlations (Table 5).

In making use of statistical modeling to assess the relationship between an outcome and predictor variables, it is generally assumed that the subjects used in the model are a sample taken from some underlying population of subjects. To address this issue, we decided the most reasonable population being represented in this data would be children ages of 0 through 6 who are on Medicaid. Thus, we limited our use of statistical models to data on Medicaid children only (N=25,149). From the Medicaid children with matched housing-age data, we randomly assigned the records to either a model development data set or a model validation data set. We compared descriptive statistics for the potential predictor variables in these two data sets to confirm their similarity and then performed a multiple logistic regression analysis to assess which potential risk factors were significant predictors of elevated blood lead levels in these children.

We began with an initial full model for the multiple regression analysis complete with the five potential risk factors, suspected two-way interactions, and three-way interactions. We modeled these predictor variables as grand-mean-centered continuous variables with the exception of the child-age variable. Child's age was modeled as a quadratic predictor because this and other studies demonstrate a peak near 3 years of age in the likelihood of a child having an elevated blood lead result. Child-age and child-age squared also were grand-mean centered to simplify the interpretation of model parameter estimates.

Using the model development data set, we followed a backward elimination procedure to eliminate the variables not significantly predictive of elevated blood lead results. Rather than use an automated method of variable elimination; we sequentially assessed a series of models, which eliminated first the three-way interactions and then the two-way interactions before assessing the statistical significance of individual variables within the model. By doing this, we ensured that a hierarchically well-formulated model was maintained and assessed throughout the elimination procedure. We then calculated assessment-of-fit statistics for the developed model. The model produced using the model-development data set was then rerun using the model-validation data set, and the parameter estimates for the variables were compared for consistency. We then applied the final form of the multiple logistic regression model to the entire augmented data set to calculate parameter estimates, p-values, odds-ratios, and their 95% confidence intervals (Table 6). We calculated the odds ratios for the continuous variables by assessing what the odds ratio was given a specific change for each continuous variable. Finally, we performed a Hosmer and Lemeshow Goodness-of-Fit Test to assess the overall fit of the model.

A similar procedure was used to develop a model predicting the natural logarithm of child blood lead levels as a continuous outcome variable and we identified the significant predictors of child blood lead levels for this data set.

Analysis for Children Matched to Soil Data

For the 484 children from the CLPPP data whose residences matched those residences with soil lead test results from the U.S. EPA and had either screened negative or confirmed positive for elevated blood lead, we calculated simple descriptive statistics for both the categorical and continuous variables in the data (Tables 7 and 8). We then created crosstabulation tables of the identified risk factors for the greater El Paso area versus the percentage of elevated child blood lead level status (Table 9) and produced their associated histograms (Appendix B, Figures 8 through 15).

Using the contingency table for grouped soil lead levels versus elevated childhood blood lead levels, we calculated a Cochran-Mantel-Haenszel statistic to test for a linear trend of soil lead on elevated blood lead status. We also calculated this statistic controlling for sex.

In preparation for the regression analysis, we created correlation and scatterplot matrices for the soil lead variable and the control variables for data visualization and assessment of correlations (Table 10).

In our next analysis, we created a simple logistic regression model to assess whether a statistical association existed between soil lead level as a continuous variable and elevated child blood lead status as the outcome of interest. From this we calculated assessment-of-fit statistics and the unadjusted odds ratio for a 500-ppm change in soil lead along with 95% confidence intervals (Table 11).

Using a multiple logistic regression model to control for covariates, we then tested whether a statistical association existed between residential soil lead levels and elevated blood lead status for children in the CLPPP data set matched to those residences. We calculated both Wald and Likelihood Ratio test statistics for this analysis. We performed these calculations while controlling for the risk factors previously identified for the greater El Paso area. Using this model, we calculated an adjusted odds ratio and 95% confidence intervals for a 500-ppm increase in residential soil lead for the outcome of elevated child blood lead status (Table 12).

We performed a Hosmer and Lemeshow Goodness-of-Fit Test to assess the overall fit of the model.

Additionally, although logistic regression is not amenable to a classic assessment for the coefficient of determination, or R-squared value, there is a statistic later referred to as the "maximum rescaled R-square" that can be applied to more general linear models. We calculated this generalized coefficient of determination for the models developed and used it to assess the predictive ability of the models.

Modeling the natural logarithm of child blood lead levels, we used ordinary least squares regression to assess whether there was a statistical association between residential soil lead results and child blood lead levels as a continuous outcome. We used this multiple linear regression to calculate both unadjusted and adjusted estimates of the change in child blood lead values with changes in soil lead level. We calculated 100 ppm, 500 ppm, and 1,000 ppm changes from an initial 250 ppm residential soil lead level while controlling for the risk factors identified for the greater El Paso area. We used diagnostic plots of model residuals to identify whether any serious problem in the linear model was apparent and performed multilevel modeling to determine whether this analytical approach altered the results of the linear modeling.

Results

Greater El Paso Results

Basic summary statistics for each of the potential risk factors used in the model are provided in Table 2. The median age for the children was 2.2 years, the average age of housing was 37 years, on average 8.7% of the percentage of the population in a child's census tract immigrated from Mexico during the period from 1990 to 2000, the average percentage of individuals in a census block group living below the poverty level was 30.6%, the average distance from a child's residence to the smelter was 9.9 miles, and the average blood lead level for the 38,258 children was 3.4 µg/dL (geometric mean 2.9 µg/dL).

Fifty-one percent of the children were male, and 97.9% were on Medicaid at the time of their blood lead test (Table 3). The largest single age group for children was 1-year-olds. A total of 463 children had confirmed elevated blood lead results between 1997 and 2002 in the greater El Paso area; 410 had blood lead levels between 10 µg/dL and 20 µg/dL, 38 had blood lead levels between 20 µg/dL and 30 µg/dL, and 15 children had blood lead levels greater than 30 µg/dL (Table 3).

The crosstabulation tables of potential risk factors versus the percentage of elevated blood lead status can be seen in Table 4 and in Figures 1 through 7 (Appendix A). The percentage of elevated child blood lead results was highest in the 3-year olds (Figure 1), and a slightly higher percentage of males than females had elevated blood lead levels (Figure 2). There appeared to be a trend of higher percentages of elevated child blood lead results with increasing housing age (Figure 3) and block-group poverty level (Figure 5). Census tracts with higher percentages of

Mexican immigration in the previous decade seemed to have had higher rates of elevated blood lead levels (Figure 4). The distance of residence from smelter versus percentage of elevated blood lead suggests children living closer to the smelter had higher percentages of elevated blood lead test results than children living farther away from the smelter (Figures 6 and 7). Seven of the 24 children (29%) living within a mile of the smelter had elevated blood lead results (Table 4).

The correlation matrix for the potential predictor variables shows that age of housing, poverty within a block group, and Mexican immigration within a census tract all had moderate to moderately high inverse correlations with distance of a child's residence to the smelter (R-values ranged from negative 0.43 to negative 0.67). Poverty, Mexican immigration, and housing age all had a moderate correlation with each other (R-values between 0.37 and 0.57) (Table 5).

The multiple logistic regression modeling for the greater El Paso data set indicated that a child's age, housing age, percentage of poverty in a child's block group, percentage of Mexican immigration in a child's census tract, and distance to smelter all had statistically significant associations with the outcome of elevated blood lead levels (Table 6). The contribution of a child's sex was not statistically significant, but was retained in the model because of the believed clinical importance of sex on elevated blood lead levels. Including sex in the model neither changed the parameter estimates for the other variables nor increased their variance inflation factors. The multiple logistic regression modeling did not suggest any significant interactions between the assessed predictor variables. The maximum rescaled R-squared value for this model equaled 0.07.

The results of the parameter estimates and odds ratios for the multiple logistic regression model, seen in Table 6, show what these measures are when statistically controlling for the other variables included in the model. Thus, the odds ratios seen in Table 6 are all adjusted odds ratios for these predictors of elevated blood lead status. Because the predictor variables were grand-mean centered, the parameter estimates and odds ratios can be interpreted as what effect a given predictor variable has on elevated blood lead status for average measures of all other predictors. This includes sex where sex is calculated as being of "neutral" sex. For example, the odds ratio for a 20-year increase in housing age is 1.269. This indicates that for a child of average age, neutral sex, average poverty in block group, average Mexican immigration in census tract, and average distance from smelter for this data set of greater El Paso, there is a 26.9% increase in the odds of the child having an elevated blood lead result associated with that 20-year increase in the age of the child's housing. As we see in Table 6, "distance from smelter" is the only parameter (or coefficient) estimate that has a negative value. This indicates that as distance from smelter increases, the odds of a child having an elevated blood lead level decreases for this data set. The extent of decrease is about 6% (0.939-1=0.061) for every mile more distant from the smelter.

The multiple *linear* regression modeling, which had natural logarithm of blood lead level as the outcome, also showed child age, housing age, poverty in block group, Mexican immigration in census tract, and distance to smelter to be highly significant. Sex was also significant with a p-value of 0.02. Even though all these variables were significant statistically, the R-squared value of the overall model was only 0.07 and indicates the model did not explain much of the total variation in specific blood lead levels in the children. Multilevel modeling for this same data set produced very similar results.

Results for Children Matched to Soil Data Analysis

Descriptive statistics for those children whose residences matched EPA soil-sampled residences can be seen in Tables 7 and 8. Fifty percent of the 484 zero to 6-year-old children were male, and 50% were female. One-year-olds were the largest single age group, and about 40% of the children were under age 2. The median age of these children was 2.6 years. About 7 out of every 8 children were on Medicaid, and no child had a blood lead level above 30 µg/dL. The median age of housing was 66 years, and the median value for poverty in a child's block group was 40.6%. The average child lived 1.9 miles from the metals smelter and lived in a census tract where 13% of the population had emigrated from Mexico in the previous decade. Twenty-three percent of these children lived at residences with soil lead levels above 500 ppm in 2003. The soil lead values of the residences of the 484 children in the Soil-Matched analysis ranged from 6 ppm to 2,180 ppm. The geometric mean for the blood lead results of these 484 children was 3.6 µg/dL.

The crosstabulation tables for the risk factors identified in the greater El Paso analysis versus elevated blood lead status in the children can be seen in Table 9. The corresponding histograms are shown in Figures 8 through 15 (Appendix B). The age group with the highest percentage of elevated blood lead results was 2-year olds with 6% of the children having a confirmed elevated blood lead status. Ten of the 13 children with elevated blood lead levels were male. Of all male children, 4.2% had a confirmed elevated blood lead status versus 1.2% of the females. All 13 children with elevated blood lead status lived in housing over 40-years old. No trend between either poverty in a block group or Mexican immigration in a census tract versus elevated blood lead status was readily apparent. Conversely, the percentage of children with elevated blood lead status did seem to increase with increasing soil lead levels. Of the children tested between 1997 and 2002 whose residences tested above 600 ppm for lead in 2003, 8.3% had elevated blood levels (see Figure 13). When viewing this comparison by sex, 5 of the 38 (or 13.2%) male children had elevated blood lead status (Figure 14). We calculated a test for linear trend using the Cochran-Mantel-Haenszel Statistic between these soil lead ordered groups and elevated blood lead status. This test suggested there was a linear trend and was statistically significant with a p-value of 0.017 (0.023 when controlling for sex).

A comparison of the correlations between soil lead levels, the control variables, and the natural logarithm for children's blood lead level can be seen in Table 10. Housing age versus soil lead level showed a coefficient of correlation, or R-value, of 0.51. Poverty and immigration had lower correlations with soil lead with R-values of 0.14 and 0.08, respectively.

The results for Medicaid children for the simple logistic regression model comparing soil lead levels and other risk factors versus elevated blood lead status can be seen in Table 11. The parameter estimate for soil lead was highly significant upon statistical testing with a p-value of 0.0002. The unadjusted odds ratio was 3.4 (95% CI, 1.8, 6.4) for a 500 ppm change in soil lead versus an elevated child blood lead status. The maximum rescaled R-square for this model equaled 0.14. The control variables had non-significant p-values of 0.2, 0.66, and 0.84 for housing age, poverty in block group, and Mexican immigration in census tract respectively when modeled individually versus elevated blood lead status. Males compared to females had an unadjusted odds ratio of 4.2 and was of borderline statistical significance at p=0.07.

The multiple logistic model, which controlled for previously identified risk factors for El Paso and tested whether soil lead level was statistically associated with Medicaid children's elevated blood status, can be seen in Table 12. The parameter estimate for soil lead was significant with a p-value of 0.01. The adjusted odds ratio was 4.5 (95% CI, 1.4, 14.2) for a 500 ppm change in soil lead versus an elevated child blood lead status. Because the model controlled for all the identified confounders, it obtained by definition the most valid, or accurate, point estimate of soil lead's coefficient and corresponding odds ratio for these data. Each of these covariates could potentially be dropped from the model, but the point estimate obtained from the full model was considered to be the "gold-standard" for soil lead's association with elevated blood lead. We checked dropping each covariate from the model to assess whether the *precision* of the estimate for soil lead could be improved upon without changing the point estimate itself. In fact, poverty and Mexican immigration could be dropped from the model without changing the point estimate for soil lead, but no improvement in precision was obtained. Housing age could not be dropped from the model without changing the point estimate toward its unadjusted value. The full model had a maximum rescaled R-squared value of 0.23. The likelihood ratio test to assess soil lead's contribution to the model indicated soil lead was a significant predictor of blood lead status with a p-value of 0.009.

The crosstabulation tables of sex versus elevated blood lead status had indicated that there may be a marked difference in the statistical relationship in this data set between soil lead values and elevated blood lead status by sex. We attempted to address this by modeling the male children and female children separately, and the results can be seen in Table 13. These results suggest a difference existed between sexes for the adjusted odds ratios of soil lead values versus elevated blood lead status in this data set. This analysis showed an odds ratio of 4.9 for males and 2.8 for females for elevated blood lead status for a 500 ppm change in soil lead levels. Although the odds ratios for both sexes were elevated, only the odds ratio for males reached statistical significance with a p-value of 0.02.

Using multiple *linear* regression on the same 426 children, we obtained estimates on the modeled change in natural logarithm of blood lead results for specific changes in soil lead levels. For a change in soil level from 250 ppm to 350 ppm, the model predicts a 0.11 μg/dL change in blood lead level; from 250 ppm to 750 ppm, a 0.57 μg/dL change; and from 250 ppm to 1,250 ppm, a 1.2 μg/dL change. Similar to the results in the larger data set, the R-squared value for this model was low, equaling 0.08. Multilevel modeling for this same data set produced nearly identical results.

Discussion

To properly interpret the results of these analyses, it is important to put the findings into a larger context and consider what has been previously shown in other studies in other locations. Although this tenet applies to the interpretation of individual studies in general, it is especially important for these findings because the statistical analyses conducted in this report were performed on data sets that were originally collected for other purposes. We conducted these analyses by synthesizing data from available data sets to address questions on the statistical relationship between risk factors and elevated blood lead status of the children in these data sets.

Studies specifically designed to assess whether soil lead levels contribute to blood lead levels in children have consistently found that soil lead contributes to children's blood lead levels (*1;17-27*). Reviews or meta-analyses of epidemiologic studies of soil lead's influence on children's blood lead levels came to the same conclusions (*28;29*). The only recent study that identified a population of children whose blood lead levels were seemingly unaffected by soil lead levels suggested this lack of association might be attributable to a low bioavailability of lead in soil in a mining community in Sweden. The same study inferred an association between soil/dust lead and child blood lead levels in an urban population of Swedish children (*30*).

For these analyses, we used logistic regression modeling, and it may be helpful to offer some additional explanation on its interpretation. The logistic regression models assess the probability of the outcome (elevated blood lead status defined as greater than 10 μg/dL) as a binary outcome (Yes or No). Therefore the interpretation of the predictor variables is accomplished using odds ratios. The use of odds ratios is common in epidemiologic studies and in studies for which a binary outcome is either required or makes sense from a clinical or scientific perspective. An odds ratio of one (1.0) would indicate that the data do not suggest a relationship between the variable and the outcome. In addition, because a certain amount of chance or variation can be expected in relationships between variables and outcomes, statisticians have developed methods to address this uncertainty. One method is to calculate the 95% confidence intervals (95% CI) to help determine whether the odds ratio is significantly different than one. The 95% CI is the range of estimated odds ratio values that has a 95% probability of including the true odds ratio for the population. A 95% confidence interval that does not include 1.0 suggests there is a statistically significant relationship between the test variable (predictor variable) and the outcome (usually a disease status Yes/No).

In our study, the observed odds ratio of 4.5 for a 500 ppm change in soil lead, when controlling for other risk factors (Table 12), indicates that for these data a 500 ppm increase in soil lead level was associated with a 4.5-times increase in the odds of a child having an elevated blood lead result. For these data, we are 95% confident that the true odds ratio lies between 1.4 and 14.2. Because the 95% confidence interval excludes 1.0, these results suggest that soil lead has a statistically significant association with elevated blood lead status.

All the statistical models developed and reported in this study had highly significant goodness-of-fit test results, yet showed a modest ability to predict outcomes as reflected in the low R-squared values seen. In the analysis of the soil-matched data, we found a statistically significant association between soil lead and blood lead test results regardless of whether we modeled the blood lead data as a binary or a continuous outcome. However, soil lead levels were better able to predict blood lead outcomes if blood lead was modeled as a binary outcome and not as a log-tranformed outcome (R-squared of 0.23 versus 0.08 respectively). This finding has been seen elsewhere (*31*).

Given the multifaceted individual behavior of children combined with the multiple pathway and multiple source nature of lead exposure, this finding is not surprising. For many children with blood lead levels that are elevated but still low, identifying a single predominant source or pathway is not always possible. It is clear that many of the important components of soil lead's contribution to a child's blood lead status were not included in our models. Hand-to-mouth behavior of individual children, pica behavior, a child's level of iron deficiency, house dust loadings, ground covering in yards, use of folk remedies containing lead, bone lead levels, home remediation or remodeling activities, and other factors can have large effects on a child's blood lead level (*32-39*).

There is nothing in our analysis of blood lead levels in El Paso children that suggests soil lead does not contribute to elevated blood lead levels in this population of children.

Uncertainties

The conclusions reached in this consultation are based on an analysis of existing data. The data used in the analysis were originally collected for other purposes. Being limited to the data available in the existing data sets could lead to (1) confounding because we were not able to control for other factors that may be related to both the risk factor in question and the outcome and (2) selection bias because we were limited to those individuals and residences already available in the data sets. The time difference between the time that the blood lead tests were performed (1997 to 2002) and when the soil lead levels were measured (2003) could lead to exposure misclassification because assumptions are made on the status of soil lead levels measured in the yards for the time period when the children would have come into contact with the soil. For these analyses, we assumed that the soil samples collected in 2003 were representative of the soil levels to which the children would have been exposed at the time that the blood lead tests were performed.

Conclusions

1. Based on the analysis of the soil-matched data, there was a significant association between soil lead and blood lead test results regardless of whether we modeled the blood lead data as a binary or a continuous outcome. A 500 ppm change in soil lead was associated with a 4.5-times increase in the odds of a child having an elevated blood lead level (>10 µg/dL).

2. Although we found a significant association between soil lead and blood lead test results regardless of whether we modeled the blood lead data as a binary or a continuous outcome, there was a difference in the extent of the model's use of soil lead to predict blood lead levels. This is not necessarily an unexpected result, considering the substantial toxicologic threat posed by the combination of multiple low-level exposures to lead from many sources and pathways.

3. On the basis of the results of our analysis, the multiple source nature of lead exposure, and review of the large body of literature on the importance of the soil/dust pathway, we have concluded that soil lead probably has a contribution to elevated blood lead levels in this population of children in El Paso, Texas.

Recommendations

Actions Completed/Ongoing

1. EPA is continuing to assess the extent of soil contamination in the El Paso area.
2. EPA, TDH, ATSDR, TCEQ, and local authorities are reviewing available bioavailability data to better define the potential public health threat posed by lead in the soil. In addition, EPA has collected environmental data on 30 residences for use in EPA's Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK) to better refine the model's predictions for a soil remediation level.
3. The Texas Department of Health has measured the blood lead levels of children (0–6 years of age) who lived in those 30 households.
4. TDH is working with the El Paso City/County Health Department to increase blood lead screenings in the community and to increase awareness by healthcare providers of the importance of screening, reporting, and follow-up of children with elevated blood lead levels.

Actions Planned

1. TDH and ATSDR will assist EPA and local health authorities in addressing community concerns pertaining to the public health significance of the lead in the soil.
2. TDH and ATSDR will evaluate additional information as needed and as data become available.

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Certification

This public health consultation was prepared by the Texas Department of Health (TDH) under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures that existed at the time the health consultation was initiated.

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Technical Project Officer, SSAB, DHAC, ATSDR

The Division of Health Assessment and Consultation, ATSDR, has reviewed this health consultation and concurs with its findings.

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Cooperative Agreement Team Supervisor, SSAB, DHAC, ATSDR

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Appendices

APPENDIX A. ABBREVIATIONS, ACRONYMS, AND INITIALISMS

The following list shows how these terms are used in this manuscript.

ATSDR	Agency for Toxic Substances and Disease Registry
CI	Confidence interval
CLPPP	Texas Childhood Lead Poisoning Prevention Program
CDC	Centers for Disease Control and Prevention
EPA	U.S. Environmental Protection Agency
GIS	Geographic Information Systems
IEUBK	Integrated Exposure Uptake Biokinetic Model for Lead in Children (EPA)
µg/dL	Micrograms per deciliter
ppm	Parts per million—equivalent to milligrams per kilogram
TCEQ	Texas Commission on Environmental Quality
TDH	Texas Department of Health
95% CI	Ninety-five percent confidence interval

Appendix B. Figures

1997–2002 Child Lead Poisoning Prevention Program Data for El Paso, TX
Children Age 0 to 6, Confirmed Elevated Blood Lead Status (>= 10 µg/dL), (N=38,256)

Figure 1

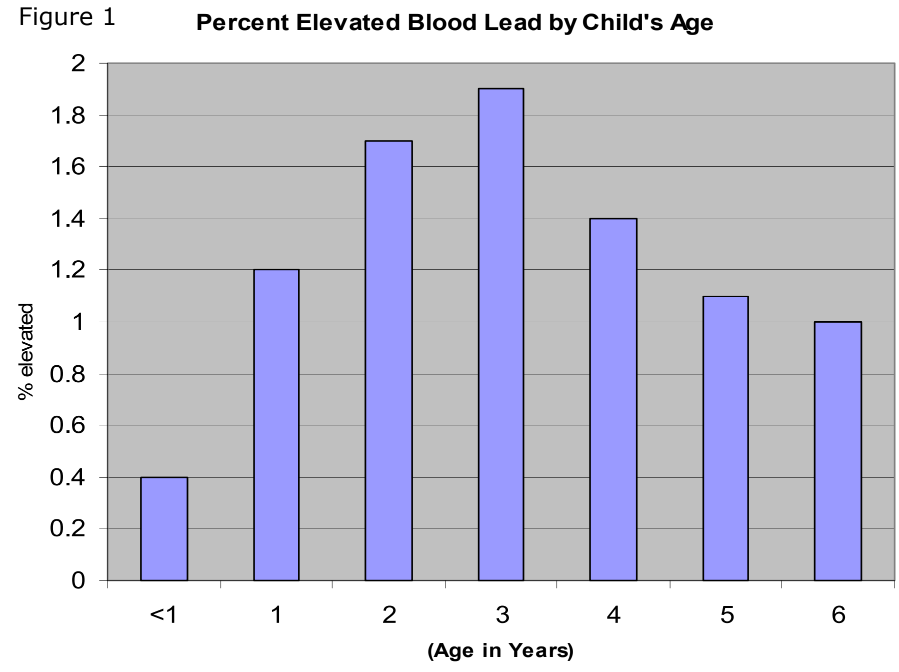
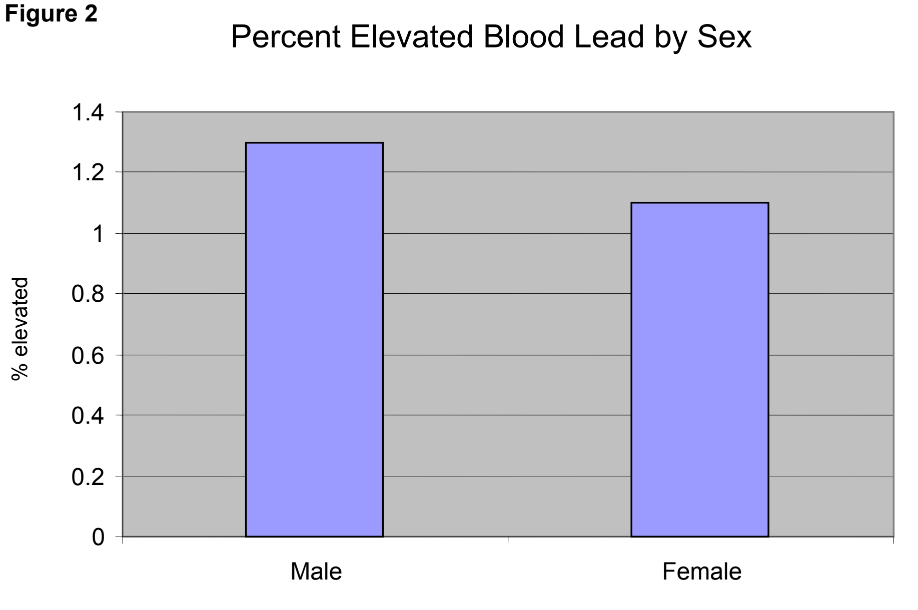
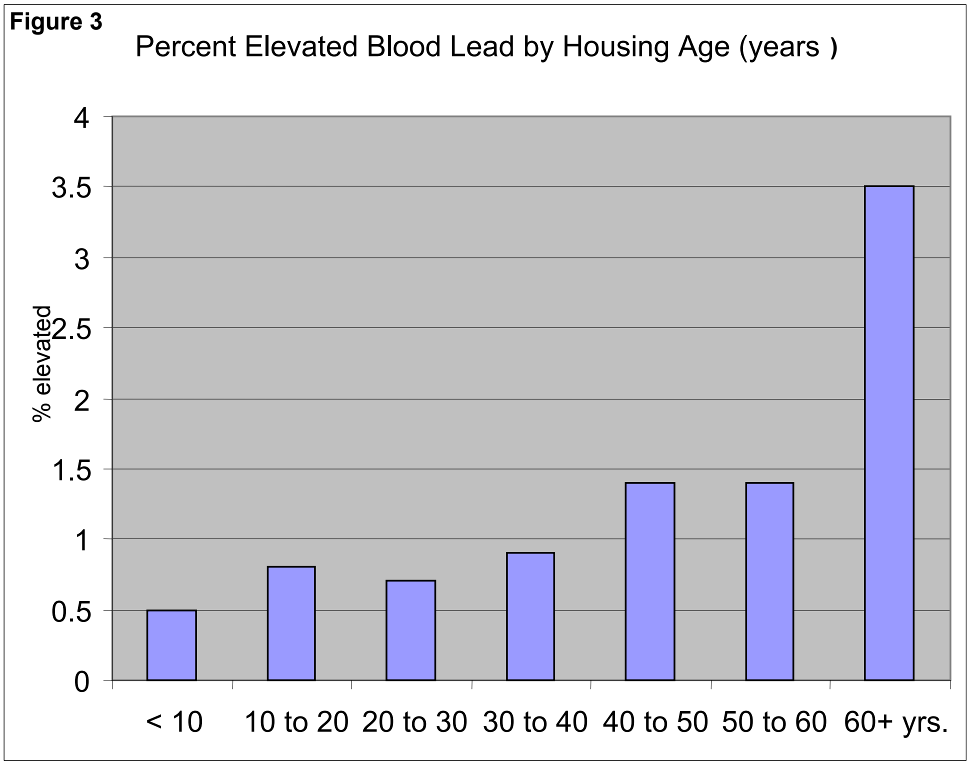


Figure 2



1997–2002 Child Lead Poisoning Prevention Program Data for El Paso, TX
Children Age 0 to 6, Confirmed Elevated Blood Lead Status (>= 10 µg/dL), (N=38,256)

Figure 3



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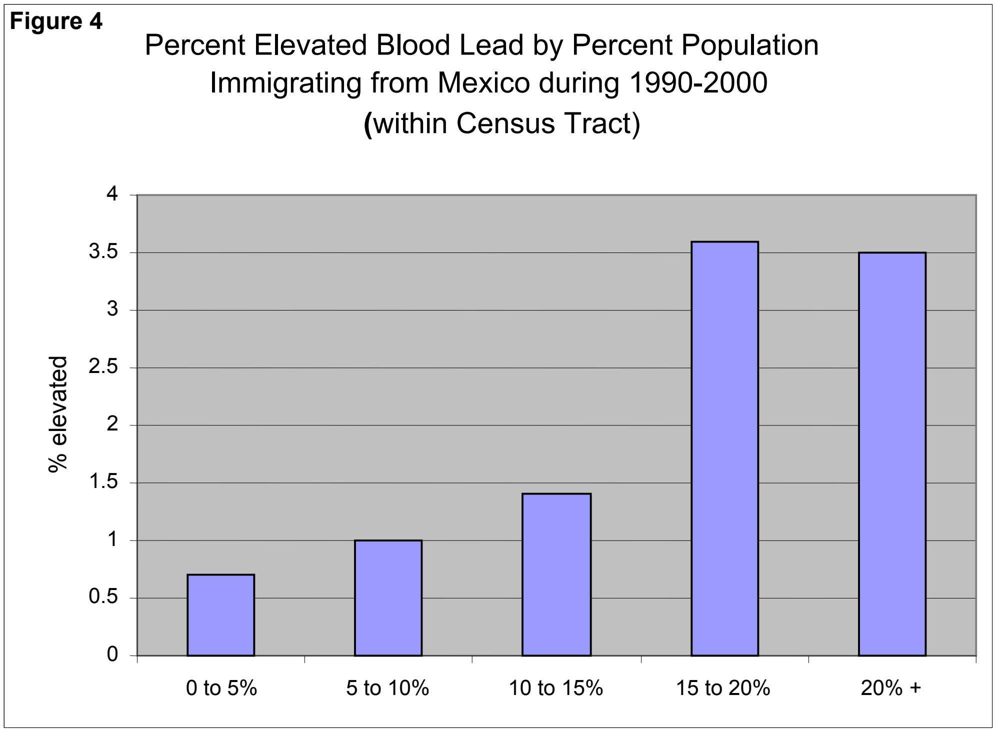
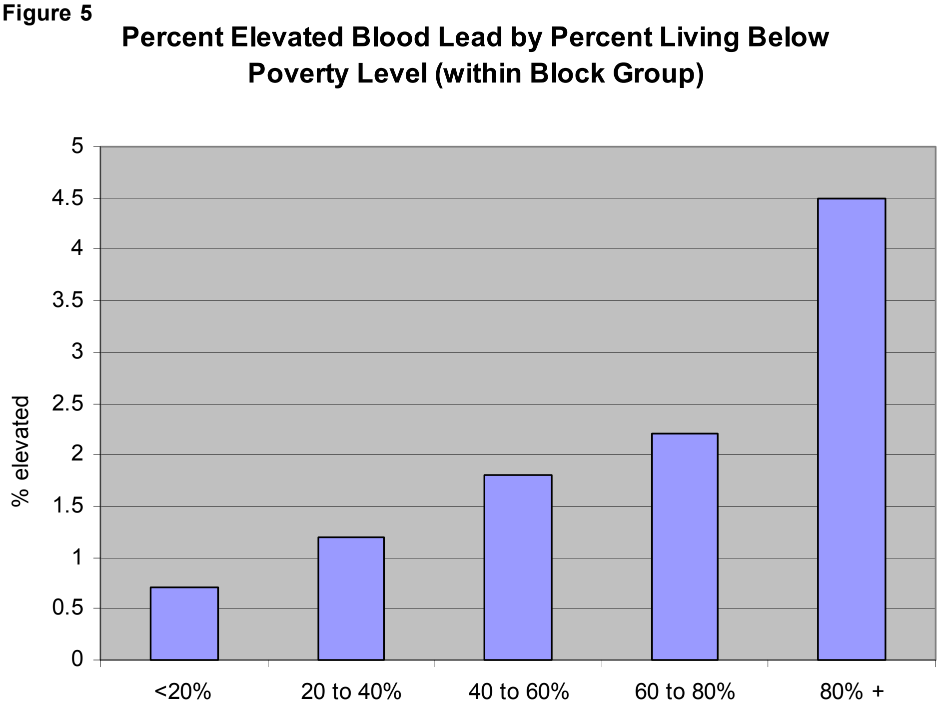


1997–2002 Child Lead Poisoning Prevention Program Data for El Paso, TX
Children Age 0 to 6, Confirmed Elevated Blood Lead Status (>= 10 µg/dL), (N=38,256)

Figure 5



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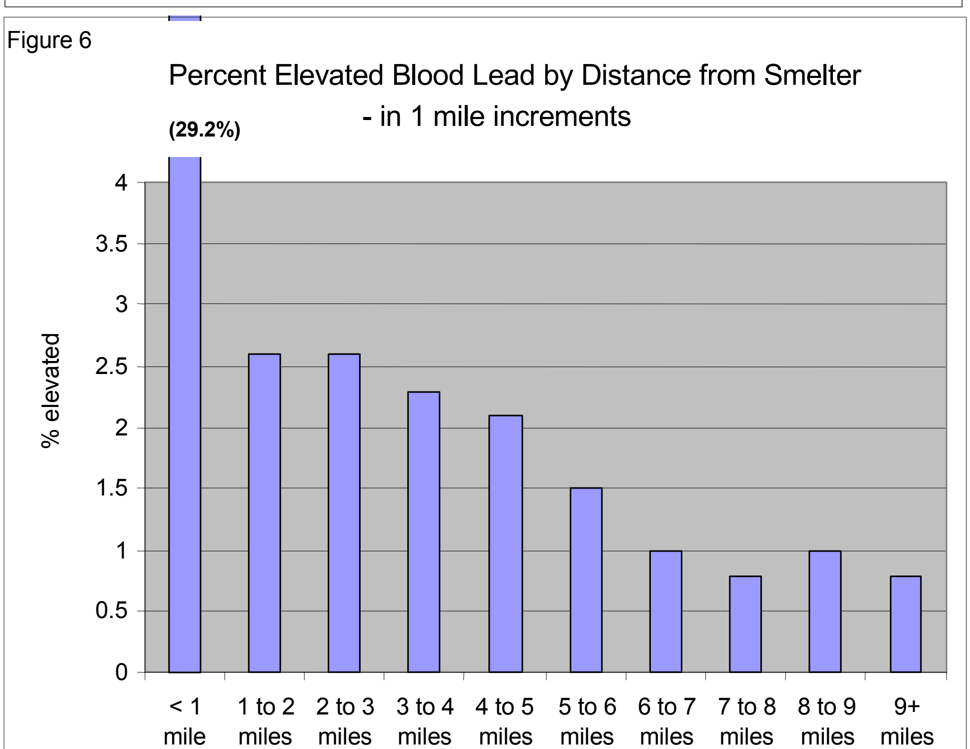
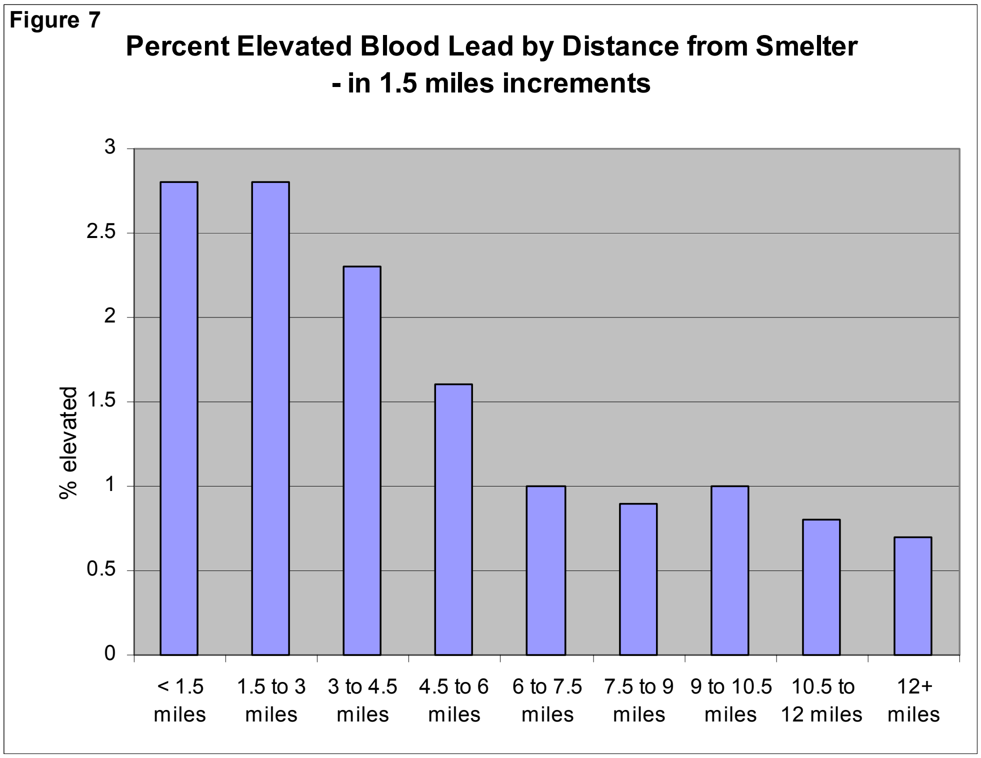


Texas 1997–2002 Child Lead Poisoning Prevention Program Data for El Paso, TX
Children Age 0 to 6, Confirmed Elevated Blood Lead Status (>= 10 µg/dL), (N=38,256)



1997–2002 Childhood Lead Poisoning Prevention P Program Data for El Paso, Texas
Percentage of Confirmed Elevated Blood Lead Status (≥10 µg/dL) for Children Aged 0 to 6 Years Whose Residences Matched EPA Soil-Sampled Residences (N=484)

Figure 8

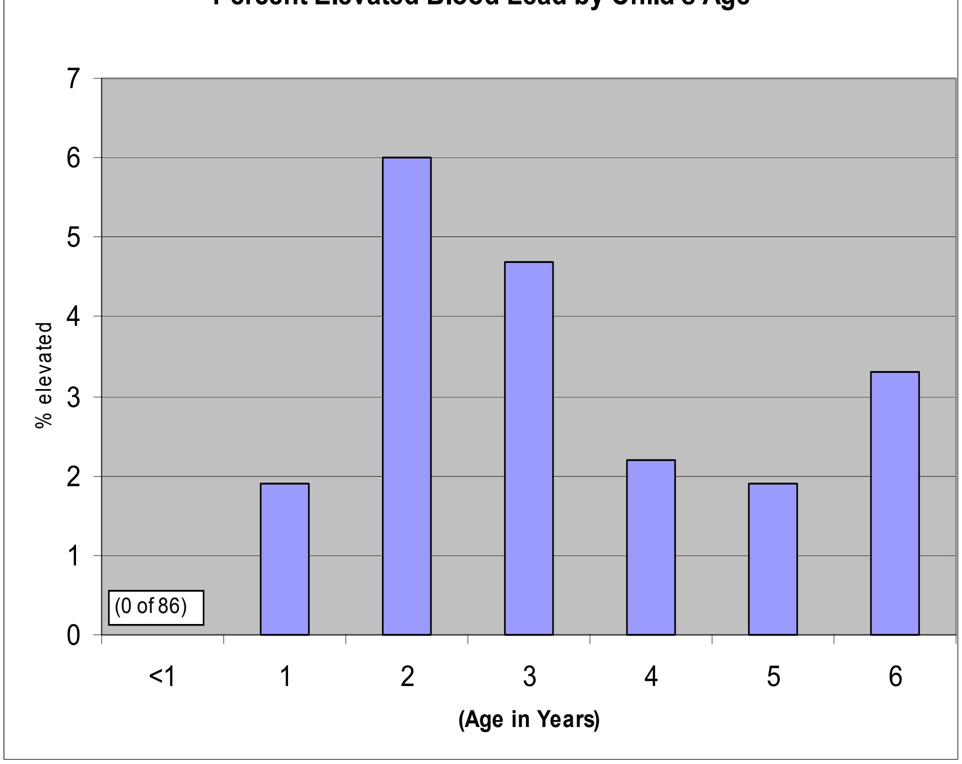
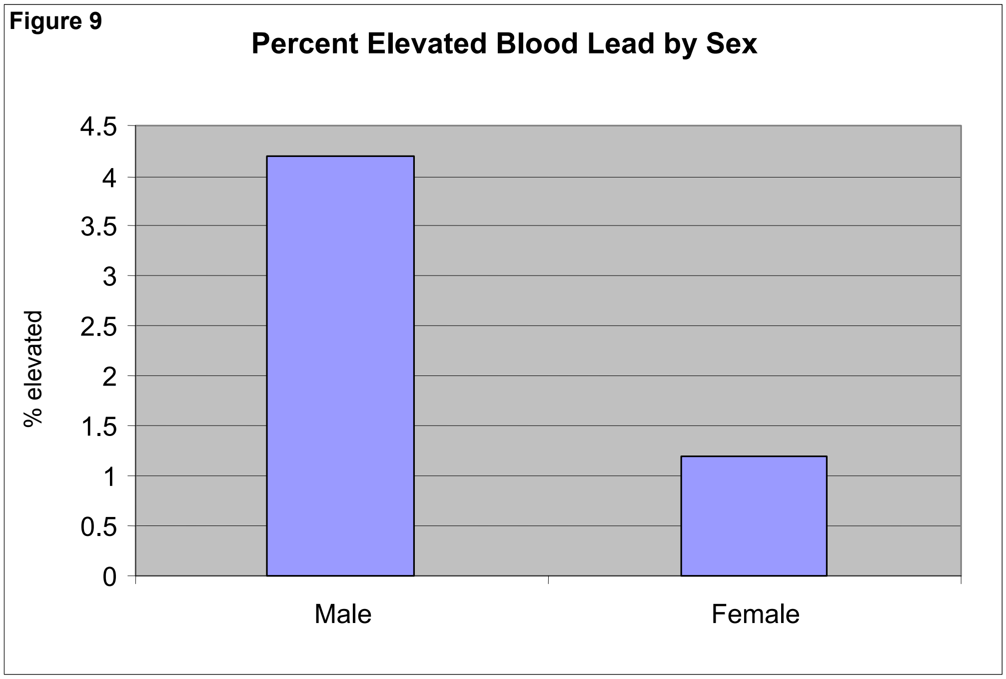
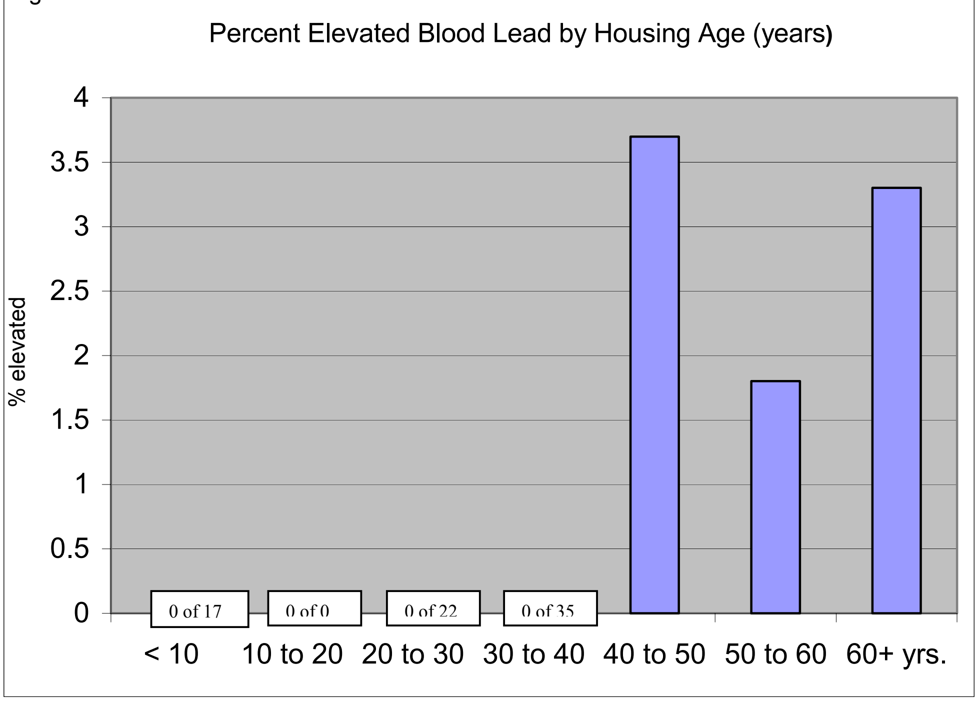


Figure 9



1997–2002 Childhood Lead Poisoning Prevention Program Data for El Paso, Texas
Percentage of Confirmed Elevated Blood Lead Status (≥10 µg/dL) for Children Aged 0 to 6 Years Whose Residences Matched EPA Soil-Sampled Residences (N=484)

Figure 10



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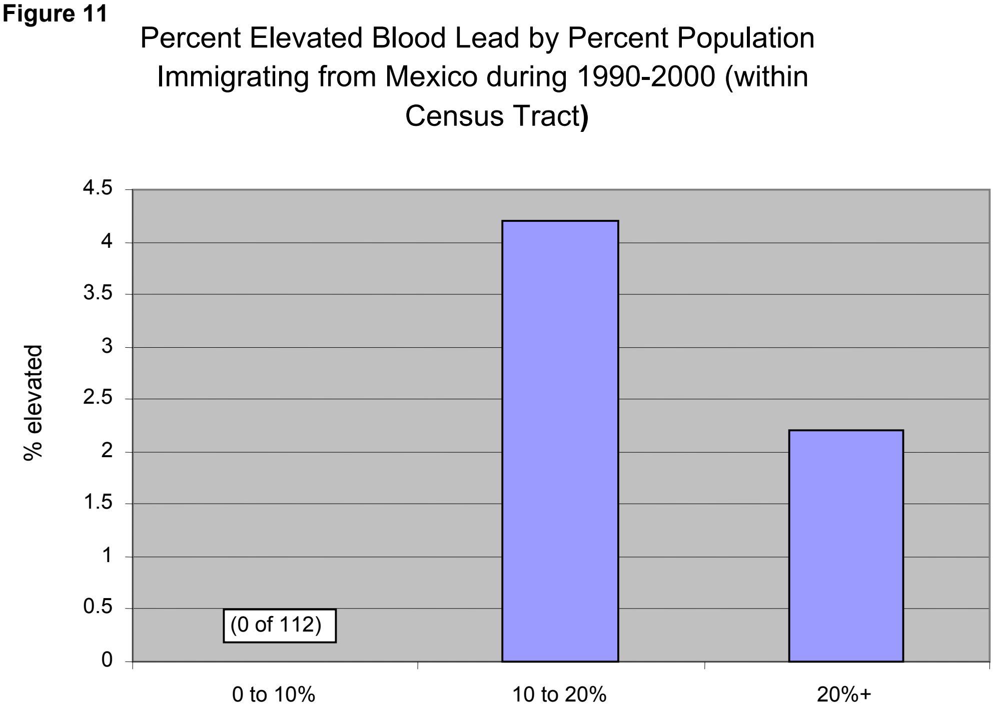


**1997–2002 Childhood Lead Poisoning Prevention Program Data for El Paso, Texas
Percentage of Confirmed Elevated Blood Lead Status (≥10 µg/dL) for Children Aged 0 to 6 Years
Whose Residences Matched EPA Soil-Sampled Residences (N=484)**

Figure 12

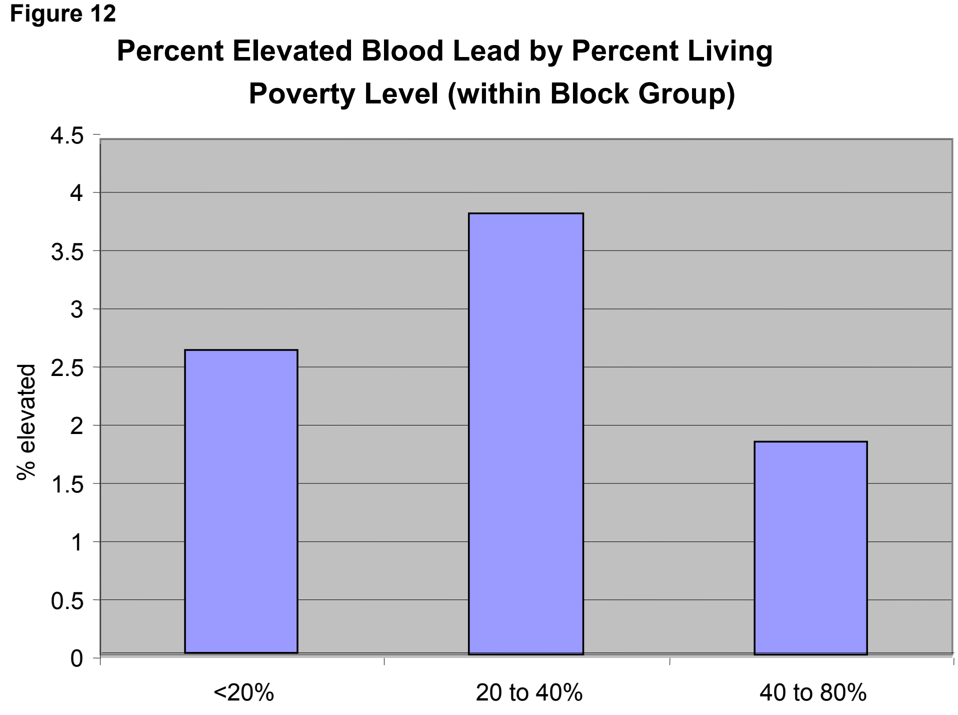
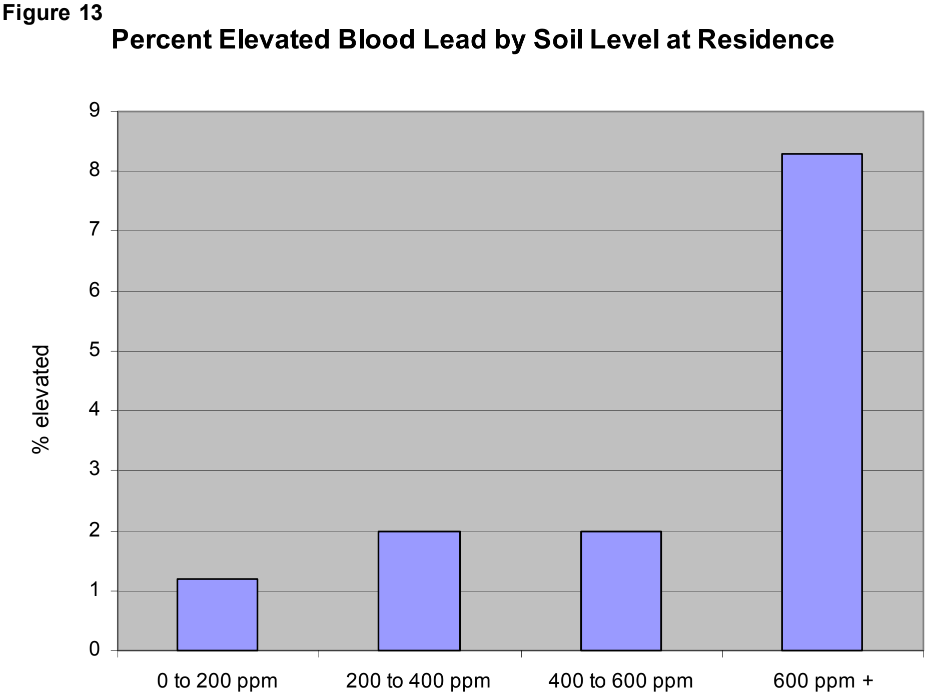


Figure 13



1997–2002 Childhood Lead Poisoning Prevention Program Data for El Paso, Texas
Percentage of Confirmed Elevated Blood Lead Status (≥10 µg/dL) for Children Aged 0 to 6 Years
Whose Residences Matched EPA Soil-Sampled Residences (N=484)

Figure 14

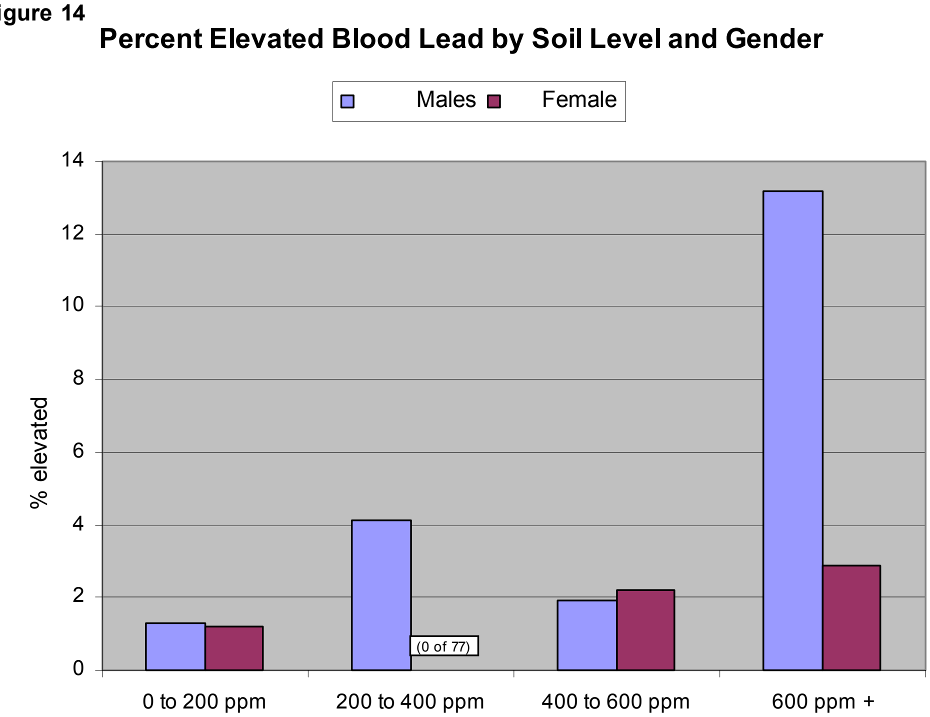
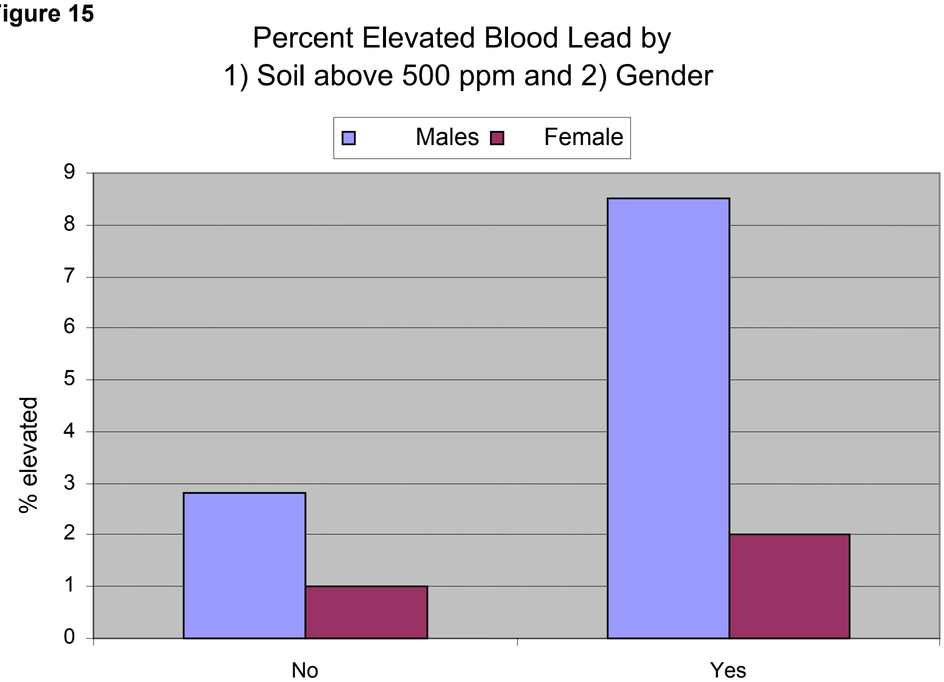


Figure 15



Appendix C.: Tables

Table 1.

Percentage of Children With Elevated Blood Lead Levels by Data Set

	N		Percentage Greater Tthan 10 μg/dL	
Data Set	Combined	Confirmed	Combined Results*	Confirmed Results+
Original CLPPP	39,145	38,665	2.3	1.2
CLPPP Geocoded	38,725	38,258	2.2	1.2
Soil Sampling Area	3,436	3,345	5.2	2.9
Soil Direct Match	497	484	5.2	2.7

* Combined results include non-elevated results, unconfirmed elevated results, and confirmed elevated results.

+ Confirmed results include non-elevated results and confirmed elevated results.

Table 2.

1997–20002 CLPPP Data For El Paso, Texas, For Children Aged 0 To 6 Years With A Valid Address Recorded
Confirmed Blood-Lead Level For Children With Elevated Blood Lead Status
N=38,258

Characteristic	N	Mean	std. dev.	Median	min.	max.
Age of child (years)	38,258	2.8	1.93	2.2	0	6.99
Age of child's housing (years)	25,772	36.7	21.06	33	1	123
Percentage of population in census tract who immigrated from Mexico in 1990–-2000	38,255	8.7	4.1	8.1	0	21.8
Percentage of population in block -group living below poverty level	38,255	30.6	16.68	29.1	0	100
Distance of residence from smelter (miles)	38,258	9.9	5.28	9.8	0.6	31.6
Blood lead level of child in micrograms/dL	38,258	3.4 (Geometric mean for blood lead = 2.9)	2.28	3	0	58

Table 3.

**1997–20-02 CLPPP for El Paso, Texas,
Children Aged 0 To 6 Years With A Valid Address Recorded
Confirmed Blood -Lead Level For Children With Elevated
Blood Lead Status
N=38,258**

Characteristic	Frequency	Percentage
Sex		
Female	18,729	49.0
Male	19,476	51.0
(information not available)	53	
Age		
Less than 1 year Old	6,954	18.2
1 year old	9,901	25.9
2 years old	5,536	14.5
3 years old	4,272	11.2
4 years old	4,529	11.8
5 years old	3,657	9.6
6 years old	3,409	8.9
On Medicaid at Time of Test		
No	822	2.2
Yes	37,436	97.9
Blood Lead Level		
Less than 10 micrograms/dL	37,795	98.8
10 to 20 micrograms/dL	410	1.1
20 to 30 micrograms/dL	38	0.1
Greater than 30 micrograms/dL	15	0.04
Elevated Blood Lead		
Yes	463	1.2
No	37,795	98.8

Table 4.

1997-20021997–2002 CLPPP for El Paso, Texas
Children Aged 0 to 6 Years
With a Valid Address Recorded
Confirmed Blood -Lead Level For Children With Elevated Test Results
N=38,258

Characteristic	N	% Elevated*
Age of child in years		
<1	6,954	0.4
1	9,901	1.2
2	5,536	1.7
3	4,272	1.9
4	4,529	1.4
5	3,657	1.1
6	3,409	1.0
Sex of child		
Male	19,476	1.3
Female	18,729	1.1
Housing age (years)		
< 10	2,319	0.5
10 to 20	3,265	0.8
20 to 30	5,202	0.7
30 to 40	3,835	0.9
40 to 50	5,000	1.4
50 to 60	3,024	1.4
>60+ yrs.	3,127	3.5
Percentage census tract population immigrated from Mexico during 1990–-2000		
0 to 5%	7,167	0.7
5 to 10%	18,601	1.0
10 to 15%	10,121	1.4
15 to 20%	1,588	3.6
>20%	778	3.5
Percentage living below poverty level in block group		
<20%	11,064	0.7
20 to 40%	18,673	1.2
40 to 60%	5,916	1.8
60 to 80%	2,468	2.2
>80%	134	4.5
Lives in area with soil testing		
No	34,913	1.1
Yes	3,345	2.9

** missing values not included in calculations/statistics*

Table 4 (continued.)

Characteristic	N	Percentage % Elevated
Distance from smelter (miles)		
< 1 mile	24	29.2
1 to 2 miles	896	2.6
2 to 3 miles	2,289	2.6
3 to 4 miles	2,639	2.3
4 to 5 miles	2,595	2.1
5 to 6 miles	2,770	1.5
6 to 7 miles	2,036	1.0
7 to 8 miles	2,037	0.8
8 to 9 miles	1,841	1.0
>9 miles	21,131	0.8
Distance from smelter (miles)		
< 1.5 miles	322	2.8
1.5 to 3 miles	2,887	2.8
3 to 4.5 miles	3,981	2.3
4.5 to 6 miles	4,023	1.6
6 to 7.5 miles	2,624	1.0
7.5 to 9 miles	3,290	0.9
9 to 10.5 miles	3,845	1.0
10.5 to 12 miles	4,644	0.8
>12 miles	12,642	0.7

** missing values not included in calculations/statistics*

Table 5.

Correlational Matrix of Potential Predictor Variables and Natural Logarithm of Blood -Lead Level for Greater El Paso Data Set N=38,258

Correlations

Variable	LNBLL	HOUSING	MEXIMMIG	POVERTY	KIDAGE	KIDAGE2	SMELTDST
LNBLL	1.0000	0.1762	0.1569	0.1641	0.0676	0.0249	-0.1714
HOUSING	0.1762	1.0000	0.3745	0.4031	0.0124	0.0146	-0.6755
MEXIMMIG	0.1569	0.3745	1.0000	0.5726	0.0045	0.0028	-0.4690
POVERTY	0.1641	0.4031	0.5726	1.0000	0.0115	0.0065	-0.4312
KIDAGE	0.0676	0.0124	0.0045	0.0115	1.0000	0.9720	-0.0098
KIDAGE2	0.0249	0.0146	0.0028	0.0065	0.9720	1.0000	-0.0105
SMELTDST	-0.1714	-0.6755	-0.4690	-0.4312	-0.0098	-0.0105	1.0000

Note:

LNBLL = natural logarithm of blood lead level.
HOUSING = age of housing.
MEXIMMIG = percentage of population in 2000 census tract immigrating from Mexico in 1990 to 2000.
POVERTY = percentage of population in 2000 block -group living below poverty level.
KIDAGE = child’s age.
KIDAGE2 = child’s age squared.
SMELTDIST = distance from smelter.

Range of possible R-values is -1 to 1.

Table 6.

Multiple Logistic Regression Results for N=25,149 Medicaid Children, Ages 0 tTo 6 Years, for 1997 to 2002 CLPPP Data for El Paso, Texas
Model Outcome Is Confirmed Elevated Blood Lead Status (≥ 10 µg/dL)
Controlling for Child's Age

Parameter	Coefficient Point Estimate	Standard Error	p-value
Intercept	-4.6937	0.0728	<.0001
Sex	0.0651	0.0576	0.259
Age of child's housing	0.0119	0.00333	0.0004
Percentage of population in block -group living below poverty level	0.00877	0.00408	0.032
Percentage of population in census tract who immigrated from Mexico in 1990–-2000	0.0409	0.0167	0.015
Distance from smelter (in miles)	-0.0628	0.023	0.006

Parameter	Change	Adjusted Odds Ratio	95% Confidence Intervals lower	upper
Sex	male vs. female	1.139	0.909	1.427
Age of child's housing	20 years older	1.269	1.113	1.446
Percentage of population in block -group living below poverty level	20% increase	1.192	1.016	1.398
Percentage of population in census tract who immigrated from Mexico in 1990—2000	5% increase	1.227	1.042	1.445
Distance from smelter	1 mile more distant	0.939	0.898	0.982

Interpretation of the Odds Ratio:
A 20- year increase in the age of child's housing was associated with a 27% increase in odds of child having an elevated blood -lead level.

Table 7.

1997-2002 CLPPP Data for El Paso, Texas, for Children Ages 0 to 6 Years With Residences Matching EPA Soil-Sampled Residences Confirmed Blood-Lead Level for Elevateds

Characteristic	N	Mean	std. dev.	Median	min	max
Age of child (years)	484	3.0	2.02	2.6	0	6.99
Age of child's housing (years)	426	63.6	25.07	65.75	1	123
Percentage of population in census tract who immigrated from Mexico in 1990-2000	484	12.9	5.15	10.5	4.1	21.8
Percentage of population in block - group living below poverty level	484	12.9	12.86	40.6	6.2	73
Distance of residence from smelter (miles)	484	1.9	0.46	1.8	1.1	4.5
Blood lead level of child in micrograms/dL	484	4.1 (Geometric mean of blood lead = 3.6)	2.57	4	0	26
Soil lead level at residence (ppm)	484	350.7	304.74	310.0	6.00	2180

Table 8.

1997–2002 CLPPP Data for El Paso, Texas,
Children Ages 0 to 6 Years With Residences Matching
EPA Soil-Sampled Residences
Confirmed Elevated Blood-Lead Status (≥ 10 µg/dL)
N=484

Characteristic	Frequency	Percent
Sex		
Female	242	50.21
Male	240	49.8
Age		
Less than 1 year old	90	18.6
1 year old	104	21.5
2 years old	67	13.8
3 years old	64	13.2
4 years old	46	9.5
5 years old	52	10.7
6 years old	61	12.6
On Medicaid at Time of Test		
No	58	12.0
Yes	426	88.0
Blood Lead Level (micrograms/dL)		
Less than 10	471	97.31
10 to 20	11	2.27
20 to 30	2	0.41
>30	0	0.0
Elevated Blood Lead		
Yes	13	2.7
No	471	97.3
Soil Lead Level at Residence (ppm)		
0 to 200	161	33.3
200 to 400	152	31.4
400 to 600	99	20.5
>600	72	14.9
Soil Lead Level at Residence ≥ 500 ppm		
Yes	110.0	22.7
No	374.0	77.3

(missing data not shown/included in calculations)

Table 9.

1997–2002 CLPPP Data for El Paso, Texas, Children Ages 0 to 6 Years With Residences Matching EPA Soil-Sampled Residences Confirmed Elevated Blood-Lead Status (≥ 10 μg/dL) N=484

Characteristic	N	% Elevated
Age of child in years		
<1	90	0.0
1	104	1.9
2	67	6.0
3	64	4.7
4	46	2.2
5	52	1.9
6	61	3.3
Sex of child		
Male	240	4.2
Female	242	1.2
Housing age in (years)		
< 10	17	0.0
10 to 20	0	0.0
20 to 30	22	0.0
30 to 40	35	0.0
40 to 50	54	3.7
50 to 60	55	1.8
>60 yrs.	241	3.3
Percentage of population immigrating from Mexico during 1990–-2000 for census tract		
0 to 10%	112	0.0
10 to 20%	236	4.2
>20%	136	2.2
Percentage living below poverty level in block group		
<20%	74	2.7
20 to 40%	154	3.9
40 to 80%	256	1.9

	Total		**Male**		**Female**	
	N	% Elevated	N	% Elevated	N	% Elevated
Soil lead level at residence in parts per million (ppm)						
0 to 200 ppm	161	1.2	74	1.3	86	1.2
200 to 400 ppm	152	2.0	74	4.1	77	0
400 to 600 ppm	99	2.0	54	1.9	45	2.2
>600 ppm	72	8.3	38	13.2	34	2.9
Soil at residence above 500 ppm						
No	374	1.9	181	2.8	191	1.0
Yes	110	5.5	59	8.5	51	2.0

(missing information not shown/included in calculations)

Table 10.

Correlational Matrix of Soil-Lead with Covariates and and Natural Logarithm of Blood -Lead Level for Soil-Matched Data Set N=484

Correlations

Variable	LNBLL	HOUSING	MEXIMMIG	POVERTY	KIDAGE	KIDAGE2	SOIL5
LNBLL	1.0000	0.1569	0.1753	0.1034	0.0742	0.0478	0.1353
HOUSING	0.1569	1.0000	0.3191	0.3269	0.0991	0.0976	0.5153
MEXIMMIG	0.1753	0.3191	1.0000	0.6846	-0.0177	-0.0242	0.0879
POVERTY	0.1034	0.3269	0.6846	1.0000	0.0123	0.0077	0.1388
KIDAGE	0.0742	0.0991	-0.0177	0.0123	1.0000	0.9746	0.0269
KIDAGE2	0.0478	0.0976	-0.0242	0.0077	0.9746	1.0000	0.0237
SOIL5	0.1353	0.5153	0.0879	0.1388	0.0269	0.0237	1.0000

Note:

LNBLL = natural logarithm of blood lead level.
HOUSING = age of housing.
MEXIMMIG = percentage of population in 2000 census tract immigrating from Mexico in 1990 to 2000.
POVERTY = percentage of population in 2000 block-group living below poverty level.
KIDAGE = child's age.
KIDAGE2 = child's age squared.
SOIL5 = soil -lead level.

Range of possible R-values is -1 to 1.

Table 11.

Simple Logistic Regression Results for N=426 Medicaid Children, Ages 0 to 6 years, for 1997 to 2002 CLPPP Data for El Paso, Texas, Matched to 2003 EPA Data on Soil-Sampling Model Outcome Is Confirmed Elevated Blood Lead Status (≥ 10 µg/dL) Unadjusted result for each parameter N = 426

Parameter	N	Coefficient Point Estimate	Standard Error	p-value	Change	Unadjusted Odds Ratios	95% Confidence Intervals lower	upper
Housing age	376	0.3964	0.310	0.20	20 years older	1.49	0.808	2.734
% Poverty	426	0.2297	0.527	0.66	20 % increase	1.26	0.448	3.533
% Mexican immigration	426	0.0580	0.300	0.85	5 % increase	1.06	0.588	1.910
Sex	426	1.4344	0.797	0.07	Male vs. female	4.2	0.881	20.00
Soil lead	426	1.2222	0.323	0.0002	500 ppm increase	3.4	1.802	6.393

Table 12.

Multiple Logistic Regression Results for 376 Medicaid Children, Ages 0 to 6 yearsYears, for 1997 to 2002 CLPPP Data for El Paso, Texas, Matched to 2003 EPA Data on Soil-Sampling
Model Outcome Is Confirmed Elevated Blood Lead Status (≥ 10 µg/dL)
Soil -Lead as Test Variable— Controlling for Child's Age, Child's Sex, Housing, Poverty, and Immigration

Parameter	**DF**	**Coefficient Point Estimate**	**Standard Error**	**p-value**	**Change**	**Adjusted Odds Ratios**	**95% Confidence Intervals lower**	**upper**
Intercept	1	-4.7508	0.6629	<.0001				
Soil lead	**1**	**1.505**	**0.586**	**0.0102**	**500 ppm**	**4.504**	**1.428**	**14.202**
Sex	1	0.6321	0.4267	0.1385	male vs. female	3.541	0.665	18.856
Child's age	**1**	**2.3465**	**1.1082**	**0.0342**				
Child's age squared	1	-0.3456	0.1734	0.0462				
Age of child's housing	**1**	**0.00439**	**0.0196**	**0.8224**				
Percentage of population in block -group living below poverty level	1	0.0047	0.0386	0.903				
Percentage of Population population in census tract who immigrated from Mexico in 1990–-2000	**1**	**-0.00742**	**0.0918**	**0.9355**				

Table 13.

Multiple Logistic Regression Results for 376 Medicaid Children, Ages 0 to 6 yearsYears, for 1997–2002 CLPPP Data for El Paso, Texas, Matched to 2003 EPA data on Soil Sampling. Model Outcome Is Confirmed Elevated Blood Lead Status (≥10 µg/dL)—Soil Lead as Test Variable, Controlling for Child's Age, Housing, Poverty, and Immigration. Modeled by Sex

MALES ONLY

Parameter	DF	Coefficient Point Estimate	Standard Error	p-value	Change	Adjusted Odds Ratios	95% Confidence Intervals lower	upper
Intercept	1	-4.1457	0.7021	<.0001				
Soil lead	1	1.5862	0.7007	0.0236	500 ppm	4.885	1.237	19.287
Child's age	1	2.5646	1.3473	0.057				
Child's age squared	1	-0.3568	0.2001	0.0746				
Age of child's housing	1	-0.00984	0.0209	0.6376				
Percentage of population in block-group living below poverty level	1	-0.00349	0.0466	0.9404				
Percentage of population in census tract who immigrated from Mexico in 1990-2000	1	0.0481	0.1079	0.6558				

FEMALES ONLY

Parameter	DF	Coefficient Point Estimate	Standard Error	p-value	Change	Adjusted Odds Ratios	95% Confidence Intervals lower	upper
Intercept	1	-8.7306	4.9525	0.0779				
Soil lead	1	1.0192	1.2132	0.4009	500 ppm	2.771	0.257	29.878
Child's age	1	2.695	4.917	0.5836				
Child's age squared	1	-0.6399	1.1179	0.567				
Age of child's housing	1	0.0782	0.0534	0.1433				
Percentage of population in block-group living below poverty level	1	0.0167	0.1259	0.8948				
Percentage of census tract population in Census Tract who immigrated from Mexico in 1990--2000	1	-0.3336	0.4541	0.4626				